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Heart rate in fetuses and neonates in normal conditions and with mild depression

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The continuous recording of fetal and neonatal heart rate gives reliable information on the condition of the fetus and neonate [7, 8, 21, 22, 23]. During delivery, in response to the different acting stimuli, marked fetal bradycardias are usually produced.

Immediately after birth, and if pulmonary ventilation starts normally, neonatal heart rate rises significantly during the first minutes of life, and then falls gradually until it becomes stabilized at values similar to those of fetal heart rate [4, 5, 6, 11, 15].

In the present study the results obtained in vigorous and mildly depressed newborns [1, 2, 3, 13] by the continuous recording of fetal heart rate during labor and of neonatal heart rate during 90 minutes after birth, are presented.

1 Material and methods

Twenty three pregnant women were studied during labor, as well as their newborns. They fulfilled the following conditions:

- Mothers without known complications and good prenatal care.
- Term pregnancies with single fetuses in vertex presentation with birthweight normal for age [17].
- All labors started, progressed and delivered spontaneously without signs of fetal distress.
- No drugs were given to the mother during labor, or to the neonate [12, 16, 18, 20].

Curriculum vitae

José Raúl Bustos, *M. D., born in Montevideo, Uruguay in 1944. Graduated as Doctor in Medicine at the School of Medicine, University of Uruguay, Montevideo in 1969. In 1971 he started postgraduate studies in Pediatrics at the School of Medicine of Montevideo, and was awarded the degree of Pediatrician in 1974. In 1965 he started working in research at the Service of Obstetrical Physiology under the direction of Professor Roberto Caldeyro-Barcia, becoming Research Assistant in 1967. At present, he has become Chief of the Section of Obstetrical Physiology of the School of Medicine, University of Uruguay.*

Since 1970 he is working as Perinatologist at the Latin American Center of Perinatology and Human Development (CLAP) fulfilling his main duties in the Neonatology Service, University Hospital, Montevideo.

He has been short-term consultant in Perinatology of the Pan American Health Organization/World Health Organization on several occasions Brazil.

The umbilical cord was clamped immediately after birth.

Seventeen neonates were vigorous at 1 and 5 minutes (Apgar score 7 or higher). Six neonates were slightly depressed at the first minute but all of them recovered at 5 minutes. Both groups are studied separately.

Fetal heart rate (FHR) was continuously recorded for at least 90 minutes before delivery

with a cardiotachometer. Uterine contractions were recorded simultaneously on the same paper, by a transcervical catheter. The record of neonatal heart rate (NHR) was started as soon as possible after delivery, and lasted for at least 90 minutes. The cardiotachometer was triggered by the ECG [19] obtained with two HON electrodes (one under the scalp and the other in the umbilical cord). Punctures of the heel (after warming) were made to obtain neonatal blood samples at 15, 30, 60 and 90 minutes of life. The infants were kept naked in an adequate room, warmed with infrared rays. Skin temperature which was controlled every 15 minutes, remained between 36 and 37°C.

The records of FHR were analyzed as follows. Baseline Fetal Heart Rate (BFHR) was measured every 2 minutes according to the method of CALDEYRO-BARCIA et al. [7]. Neonatal heart rate was measured every 30 seconds, and the average for every 4 consecutive values was calculated. For the statistical analysis of heart rate, the averages corresponding to minutes 60, 30 and 8 before delivery, and minutes 10, 50 and 80 after birth were chosen. The "t" test for dependent samples and the linear correlation test were used.

2 Results

Figure 1 shows the average values of BFHR and NHR corresponding to 17 vigorous newborns (APGAR scores 7—10 at the first and fifth minutes of life).

No major variations were found in the average values of BFHR in the time period studied. **No statistically significant differences were found in the BFHR of the same fetus at 60, 30 and 8 minutes before delivery** (Fig. 2).

This result indicates that the BFHR of each fetus remains within a given range during the last 60 minutes preceding delivery. **A nonsignificant decrease in BFHR occurred during the 6 minutes preceding birth** (Fig. 1).

After birth the average values of NHR were higher than the fetal ones (Fig. 1). This postnatal increase in heart rate **(32 beats/min)** is statistically significant when BFHR values 30 minutes before delivery are compared with NHR values recorded 10 minutes after birth (Fig. 3). No correlation was found between the pair of values corresponding to each infant. **A significant negative linear correlation (Fig. 4) was found between values of BFHR 30 minutes before delivery and the amplitude of the**

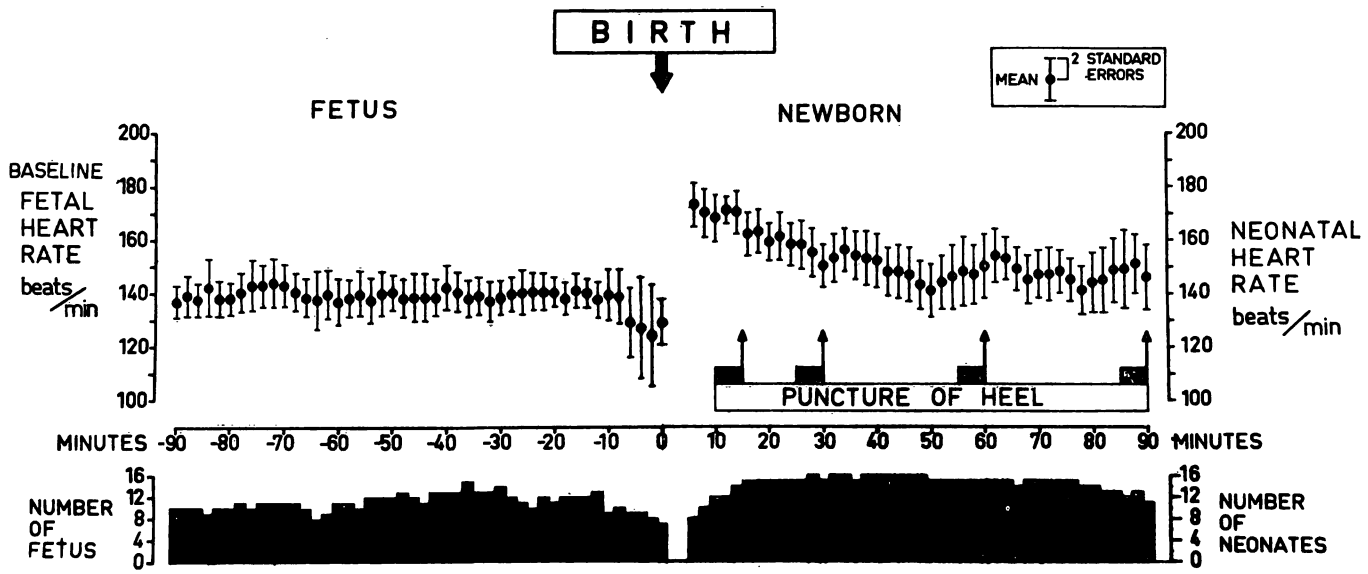


Fig. 1. Average values of 17 normal labors and corresponding neonates. Fetal heart rate is stable during the 90 minutes preceding delivery. After birth there is a sudden and marked rise in neonatal heart rate followed by a gradual fall lasting 50 minutes. Neonatal heart rate then became stable at a level similar to that of Baseline Fetal Heart Rate (BFHR). Puncture of the heel caused a transient rise in heart rate.

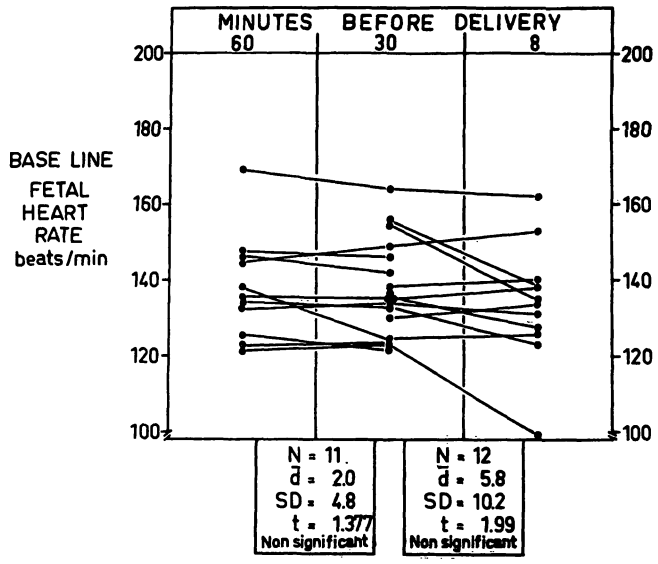


Fig. 2. No significant differences are found in FHR at 60, 30 and 8 minutes before delivery. The BFHR of each fetus remains within a given range.

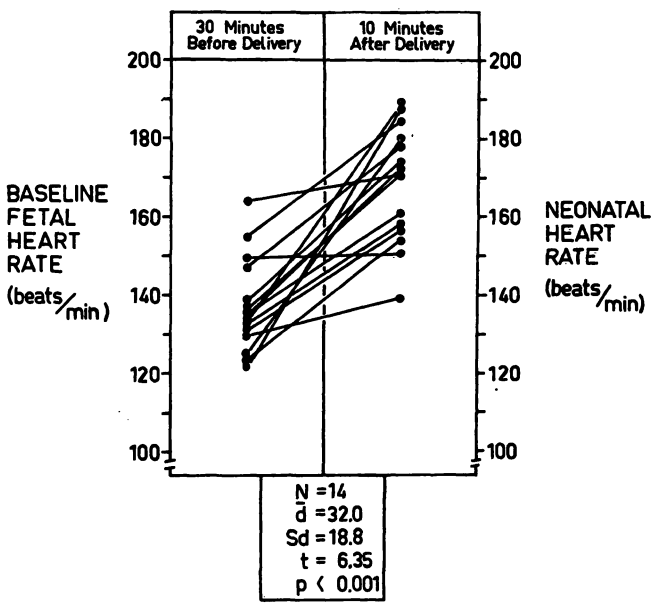
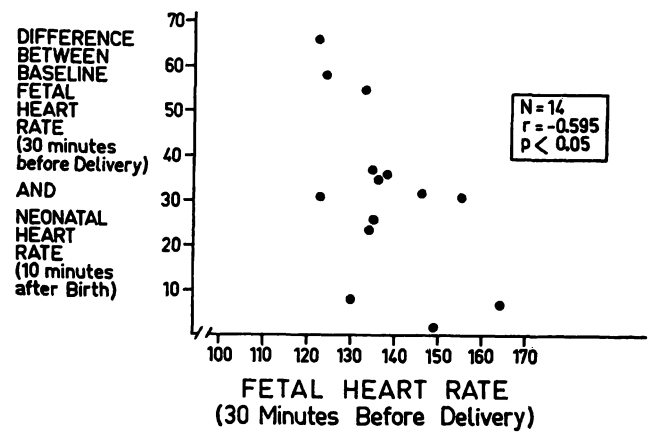


Fig. 3. Neonatal heart rate (NHR) 10 minutes after birth is significantly higher than BFHR 60 minutes before delivery.



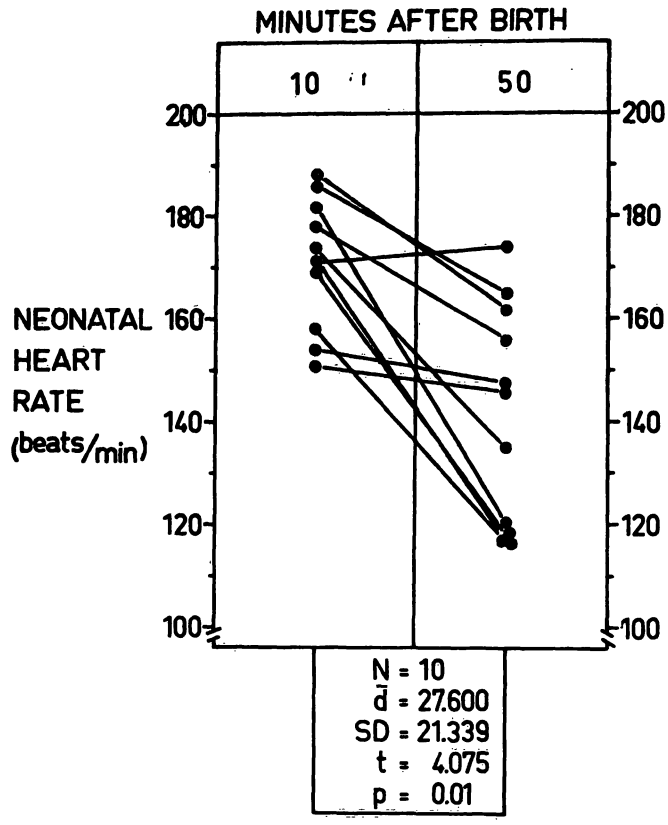


Fig. 5. Fifty minutes after birth, NHR is significantly lower than 10 minutes after birth.

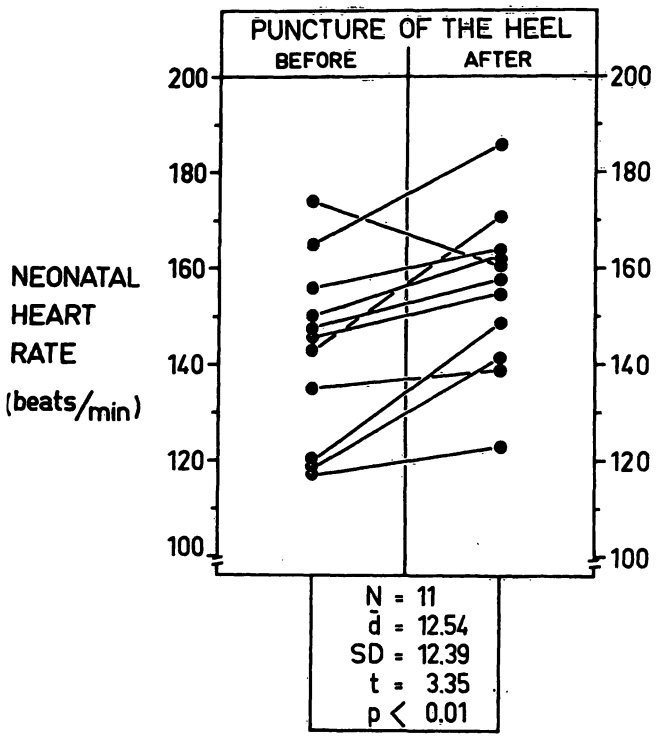


Fig. 6. Puncture of the heel causes a significant rise in NHR.

Fig. 4. The higher the BFHR, the lower the increment in NHR occurring after birth.

Tab. I. Blood from umbilical artery at birth.

	pH	P_{CO_2}	Base Excess	P_{O_2}
Vigorous				
N	17	13	13	14
$\bar{X}$	7.28	46.8	—4.0	24.6
SD	0.10	12.8	3.4	8.9
SE	0.22	3.5	0.9	2.4
Slightly depressed				
N	4	4	4	4
$\bar{X}$	7.27	56.5	—4.5	22.8
SD	0.14	27.6	1.7	6.4
SE	0.07	13.8	0.9	3.2
	t = 0.130	t = 1.00	t = 0.262	t = 0.394

Not significant

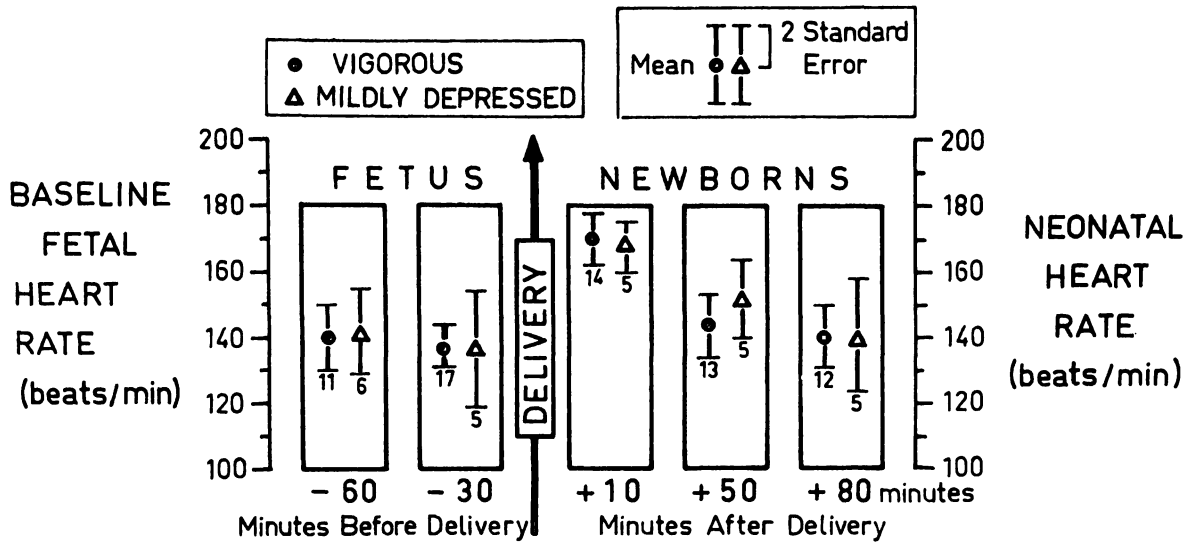


Fig. 7. There is no significant difference in heart rate (fetal or neonatal) between infants which were vigorous or slightly depressed at the first minute after birth.

increase occurring after birth as measured in Fig. 3. After this initial increase, NHR starts a **gradual fall, lasting about 50 minutes and then becomes stable at a level similar to that of fetal heart rate** (Fig. 1). The average BFHR at 30 minutes before delivery was not significantly different from NHR at 50 minutes after birth.

NHR average values at 10 and 50 minutes after birth were compared: the difference was significant ($p < 0.01$) (Fig. 5). No difference was found between NHR values at 50 and 80 minutes after birth.

Figure 1 shows that puncture of the heel causes an increase in NHR. The difference between NHR before and after the punctures is significant (Fig. 6). The heart rate of 6 infants which were slightly depressed at the first minute of life (APGAR score 4—6) but vigorous at the fifth minute, was analyzed with the same methods described. The corresponding values of BFHR and NHR are not significantly different from those of the group of 17 neonates vigorous from the first minute (Fig. 7). In addition, no significant differences were found between both groups in the P_{O_2}, P_{CO_2}, pH and Base Excess of blood of umbilical artery clamped immediately after birth (Tab. I).

3 Discussion

The cases chosen for this study have been carefully selected with the aim of establishing the "normal" pattern of fetal and neonatal heart

rate. Therefore, all newborns were vigorous at the fifth minute, spontaneously born, term infants whose mothers had no known pathologies and had not received any medication during labor.

Our results suggest that **BFHR follows a stable pattern during the 90 minutes preceding delivery,** at values which agree with those already described (Figs. 1 and 2) [11].

The individual study of these cases shows a certain dependence between values of BFHR at the end of labor, and the preceding ones (Fig. 2).

The transient rise in NHR during the first minutes of life is most probably due to the stress of the last stages of labor [5, 6, 15].

The lack of correlation between values of fetal and neonatal heart rates suggests that an independent pattern is established after birth. From the data obtained we may state that 50 minutes after birth there is a relative stabilization of NHR.

The average values of NHR reported by BUSTOS and GRISARD [5, 6] were lower than those presented in this paper. Also, stabilization was reached earlier (at 30 minutes) [5, 6]. It should be pointed out that in that study [5, 6] the mothers received analgesic drugs, and no punctures of the heel of the newborn were made. This last maneuver has been shown to cause an increase in heart rate (Fig. 6).

In the present paper no difference in NHR was found between vigorous and slightly depressed newborns which had all recovered at the fifth minute. In a group of severely depressed neonates (APGAR score 6 or less at the first and fifth minutes of life), BUSTOS and GRISARD [5, 6] reported that NHR was significantly higher than in a control group of vigorous neonates. This difference lasted for at least 30 minutes. The higher NHR of the neonates which had undergone perinatal asphyxia may be interpreted as a rebound tachycardia occurring in the recovery period [5, 6, 9, 10, 14, 15].

4 Conclusions

1. In normal term labors BFHR remains stable from 90 until 10 minutes before delivery.
2. There is a tendency for BFHR to fall during the last 6 minutes preceding birth.
3. The average values of neonatal heart rate (NHR) at 10 minutes of life, are significantly higher than those of BFHR.
4. NHR is stabilized 50 minutes after delivery, at similar levels to those of BFHR.
5. In the group of slightly depressed newborns at the first minute of life, fetal and neonatal heart rates were not very different from values corresponding to vigorous newborns.

Summary

The continuous recording of fetal and neonatal heart rate gives reliable information on the condition of the fetus and neonate.

In the present study the results obtained in vigorous and mildly depressed newborns, by the continuous recording of fetal heart rate during labor and of neonatal heart rate during 90 minutes after birth, are presented.

Twenty three pregnant women were studied during labor, as well as their newborns. They fulfilled the following conditions:

- Mothers without known complications and good prenatal care.
- Term pregnancies with single fetuses in vertex presentation with birthweight normal for age.
- All labors started, progressed and delivered spontanously without signs of fetal distress.

No drugs were given to the mother during labor or to the neonate. The umbilical cord was clamped immediately after birth. Seventeen neonates were vigorous at 1 and 5 minutes (APGAR score 7 or higher). Six neonates were slightly depressed at the first minute but all of them recovered at 5 minutes. Both groups are studied separately.

Figure 1 shows the average values of BFHR and NHR corresponding to 17 vigorous newborns (APGAR scores 7—10 at the first and fifth minutes of life).

No major variations were found in the average values of BFHR in the time period studied. **No statistically significant differences were found in the BFHR of the same fetus at 60, 30 and 8 minutes before delivery (Fig. 2). A decrease in BFHR occurred during the 6 minutes preceding birth (Fig. 1).**

After birth the average values of NHR were higher than the fetal ones **(Fig. 1).** This **post-natal increase in heart rate (32 beats/min)** is statistically significant when BFHR values 30 minutes before delivery are compared with NHR values recorded 10 minutes after birth **(Fig. 3).** After this initial increase, NHR starts a gradual fall, **lasting about**

50 minutes and then becomes stable at a level similar to that of fetal heart rate (Fig. 1).

Figure 1 shows that puncture of the heel causes an increase in NHR. The difference between NHR before and after the puncture is significant **(Fig. 6)**. The heart rate of 6 newborns which were slightly depressed at the first minute of life (APGAR score 4—6) but vigorous at the fifth minute, are not significantly different from those of the vigorous group of 17 neonates **(Fig. 7)**.

The cases chosen for this study have been carefully selected with the aim of establishing the "normal" pattern of fetal and neonatal heart rate.

We concluded that in normal term labors BFHR remains stable from 90 until 10 minutes before delivery; there is a tendency to fall during the last 6 minutes preceding birth.

Immediately after birth, neonatal heart rate rises significantly, then falls gradually and becomes stabilized 50 minutes after delivery, at levels similar to those of BFHR.

Keywords: Baseline, fetal heart rate, medicaments (during labor), neonatal heart rate, normal deliveries, normal pregnancies vigorous newborns.

Zusammenfassung

Herzfrequenz des Feten und Neugeborenen bei normalen Bedingungen und bei leichter Beeinträchtigung

Die kontinuierliche Registrierung der Herzfrequenz des Feten und des Neugeborenen gibt verläßliche Informationen über deren Befinden. In der vorliegenden Arbeit werden die Ergebnisse der kontinuierlichen Herzfrequenzregistrierung während der Fetalzeit, während der Geburt und während der Neugeborenenperiode bis 90 Minuten nach der Geburt vorgestellt, die man bei lebensfrischen und leicht deprimierten Neugeborenen erhielt.

23 Kreißende und ihre Kinder wurden untersucht. Die Bedingungen waren folgende:

— Mütter ohne bekannte Komplikationen und mit guter Schwangerenfürsorge.
— Termingerechte Schwangerschaften ausschließlich mit Schädellage und mit einem der Norm entsprechenden Geburtsgewicht.
— Alle Geburten waren spontan, ohne Zeichen einer Beeinträchtigung des Feten.

Den Müttern und Neugeborenen wurden während der Geburt keinerlei Medikamente verabreicht. Die Nabelschnur wurde unmittelbar nach der Geburt abgeklemmt. 17 Neugeborene waren lebensfrisch nach 1 und 5 Minuten (APGAR-Score 7 oder höher). 6 Neugeborene waren leicht deprimiert nach 1 Minute, doch alle erholten sich nach 5 Minuten. Beide Gruppen wurden getrennt untersucht.

Fig. 1 zeigt die Durchschnittswerte der basalen fetalen Herzfrequenz (BFHR) und des neonatalen Herzfrequenz-(NHR), die sich auf die 17 lebenskräftigen Neugeborenen (APGAR-Scores 7—10 in der 1. und 5. Minute) beziehen.

Keine stärkeren Schwankungen wurden in den Durchschnittswerten der BFHR während der Untersuchungszeit gefunden. **Keine statistisch signifikanten Unterschiede der BFHR wurden beim gleichen Feten 60, 30 und 8 Minuten vor der Geburt gefunden (Fig. 2). Eine Verminderung der BFHR ergab sich während der 6 der Geburt vorangehenden Minuten (Fig. 1).**

Die Durchschnittswerte der NHR waren nach der Geburt höher als die in der fetalen Zeit **(Fig. 1)**. Diese **postnatale Zunahme der Herzfrequenz (32 Schläge/min.)** ist statistisch signifikant, wenn man die 30 Minuten vor der Entbindung erhaltenen BFHR Werte mit den 10 Minuten nach der Geburt registrierten NHR Werten vergleicht **(Fig. 3)**. Nach anfänglicher Zunahme fällt die NHR graduell während 50 Minuten und **stabilisiert sich dann in etwa einer Höhe der fetalen Herzfrequenz (Fig. 1).**

Fig. 1 zeigt, daß die Punktion der Ferse ein Ansteigen des NHR verursacht. Der Unterschied der NHR vor und nach der Punktion ist signifikant **(Fig. 6)**. Die Herzfrequenz von 6 Neugeborenen, die in der ersten Minute leicht deprimiert (APGAR-Score 4—6) jedoch in der 5. Minute lebensfrisch waren, unterscheidet sich nicht signifikant von denen der Gruppe von 17 lebensfrischen Neugeborenen **(Fig. 7)**.

Der Zweck der Untersuchung dieser Fälle bestand darin, Normwerte für die Herzfrequenz im Fetal- und Neugeborenenalter zu gewinnen.

Wir folgerten, daß bei termingerechten Geburten die BFHR von der 90. bis 10. Minute vor der Geburt konstant bleibt. In den 6 Minuten vor der Geburt besteht eine abfallende Tendenz.

Unmittelbar nach der Geburt steigt die Herzfrequenz des Neugeborenen signifikant an, fällt dann graduell und stabilisiert sich 50 Minuten nach der Geburt in einer der BFHR entsprechenden Höhe.

Schlüsselwörter: Basalfrequenz, Geburt (normale), Herzfrequenz (Fet), Herzfrequenz (Neugeborenes), Medikamente (sub partu), Neugeborenes (lebensfrisch), Schwangerschaft (normale).

Résumé

Fréquence cardiaque chez le foetus et le nouveau-né dans des conditions normales et en présence d'une légère dépression

L'enregistrement continuel de la fréquence cardiaque foetale et néonatale donne une information précise sur la condition du foetus et du nouveau né.

Dans cette étude on présente les résultats obtenus chez des nouveaux nés vigoureux et légèrement déprimés, par l'enregistrement continuel de la fréquence cardiaque foetale pendant l'accouchement et de la fréquence cardiaque néonatale au cours des premières 90 minutes après la naissance.

On a enregistré vingt-trois femmes enceintes pendant l'accouchement, aussi bien que ses nouveaux nés. Ils remplissaient les conditions suivantes:

— Mères sans aucune complication connue et avec une attention prénatale soignée.
— Grossesses à terme avec des foetus uniques en présentation de vertex, et d'un poids à la naissance normal pour l'âge.
— Le commencement, la progression et la terminaison de tous les accouchements furent spontanés, sans aucun signal de détresse foetale.

Aucune médication fut administrée aux mères pendant l'accouchement, et non plus aux nouveaux nés. Le cordon ombilical fut lié immédiatement après la naissance. Dix-sept nouveaux nés étaient vigoureux à la lère. et à la 5ème minute (Apgar 7 ou supérieur). Les autres six étaient légèrement déprimés à la première minute mais tous se sont récupérés à la 5ème. Les deux groupes furent étudiés séparément.

La **Fig. 1** montre les moyennes de la fréquence cardiaque foetale de base (FCFB) et de la néonatal (FCN) des 17 nouveaux nés vigoureux (Apgar 7—10 à la lère. et à la 5ème. minute).

Au cours du temps étudié, on n'a pas trouvé des variations importantes de la fréquence cardiaque foetale de base (FCFB). **Il n'y a pas des différences statistiquement significatives chez un même foetus aux 60, 30 et 8 minutes avant l'accouchement (Fig. 2). Il y a eu une diminution de la FCFB dans les 6 dernières minutes avant la naissance (Fig. 1).** Après la naissance, les moyennes de la FCN furent plus élevées que celles du foetus **(Fig. 1). Cet accroissement post-natal de la fréquence cardiaque (32 battements/minute)** est statistiquement significatif quand on fait la comparaison des chiffres de la FCFB 30 minutes avant la naissance, avec les moyennes de la FCN 10 minutes après celle-ci **(Fig. 3).** Ensuite, la FCN commence à diminuer graduellement, **et depuis 50 minutes elle reste fixée à un niveau semblable à celui de la FCF (Fig. 1).**

La **Fig. 1** montre que la ponction du talon cause un incrément de la FCN. La différence entre la FCN avant et après la ponction est significative **(Fig. 6).** La fréquence cardiaque des 6 enfants qui étaient légèrement déprimés à la première minute (Apgar 4—6) mais récupérés à la 5ème, n'est pas significativemente différente de celle du groupe vigoureux (17 nouveaux nés) **(Fig. 7).**

Les cas choisis pour cette étude ont été soigneusement sélectionnés pour établir un patron "normal" de la FCF et de la FCN.

Nous sommes arrivés à la conclusion que la FCFB demeure la même dès 90 jusqu'aux 10 minutes avant la naissance. Elle montre une tendance à tomber pendant les 6 minutes qui précèdent celle-ci.

Immédiatement après la naissance, la FCN augmente significativement, pour retomber graduellement et devenir stable depuis 50 minutes à des niveaux similaires à ceux de la FCFB.

Mots-clés: fréquence basale, fréquence cardiaque (nouveau-né), fréquence cardiaque (foetus), grossesse (normale), médicaments (sub partu), naissance (normale), nouveau-né (sain).

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